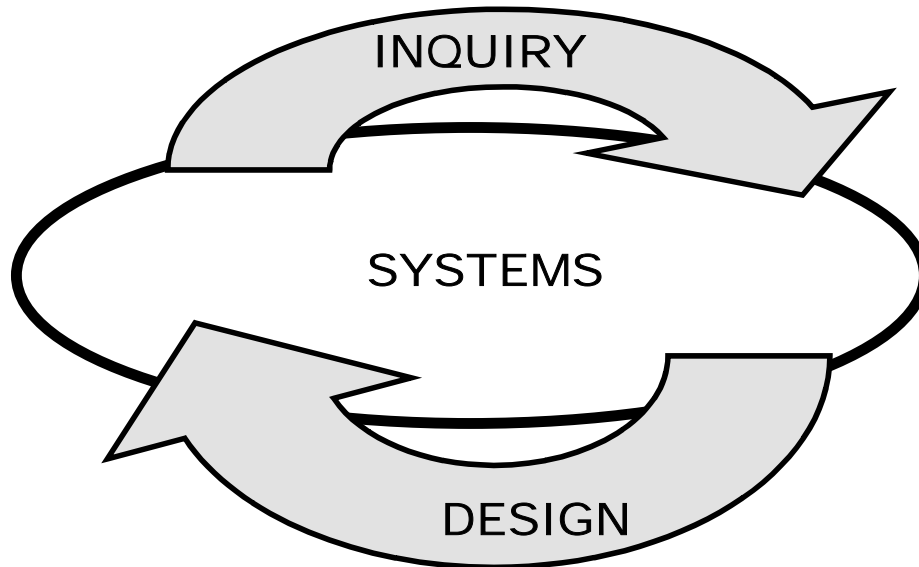


# What is SCIENCE?

It is NOT “to know.” It is closer to “to think.”



(from OSPI Science EALRs and WASL)

What can students learn by inquiry?

1. They can learn about ***inquiry***: using inquiry to learn the nature of science.

*Wrap a rubber band around an empty cardboard box, use pencils and tape to stretch or tighten the rubber band, and make some observations.*

2. They can learn about ***systems***: using inquiry to learn science concepts.

*Wrap a rubber band around a box, slide a pencil under the rubber band, and wrap one or more loops of rubber band around the pencil (you can use the tape to hold the pencil in place). If you pluck the rubber band you should hear a musical note. What happens to the note that you hear as you wrap more loops of rubber band around the pencil?*

3. They can learn about ***design***: “challenge” inquiry to solve a specific problem.

*Use a rubber band, a cardboard box, a pencil, and some tape to make a one-string “guitar” that you can tune (you have to be able to change the note). See if you can make a guitar that plays the note “E” which is the same as the low note on the real guitar in the classroom.*

## What is INQUIRY? It comes in many shades.

Science instruction can be done in a variety of ways, each using inquiry to different degrees. The degree of inquiry-ish-ness of a lesson can be *approximately* gauged by what the teacher does and the students do. The following two statements are somewhat overstated, but they are still useful guides for instruction:

- As an inexact but useful rule of thumb, the less the ideas originate from the teacher and the more they originate from the students, the more inquiry is being done.
- As another sloppy but useful generalization, science education research suggests that students learn and retain science concepts better when they originate in inquiry mode.

With that in mind, one can categorize science investigations by levels of inquiry:

|    | <b>The teacher does...</b>   | <b>The students do...</b>  |
|----|--|--|
| 1  | Provides “opportunity to learn” (usually time, space, and equipment) and facilitates discussion              | Play, generate questions, investigate, talk, play, ask questions, investigate, etc.                                |
| 2  | The above AND models methods of scientific investigation   | Generate questions, investigate, talk, etc., while emulating instructor  |
| 3  | The above AND asks questions aimed at encouraging study of a specific topic                                  | Investigate and talk in the search for answers to questions from the instructor                                    |
| 4  | The above AND asks a specific question or provides an hypothesis for study                                   | Students devise methods of investigation of the question or hypothesis for study                                   |
| 5  | The above AND suggests a method of study or investigation  | Students work within guidelines laid out by instructor to investigate given topic                                  |
| 6  | The above AND asks guiding questions designed to lead students toward an answer to the overarching question  | Students devise smaller investigations to find answers to small questions as steps toward answering a big question |
| 7  | The above AND provides step by step guidelines for intermediate investigations                               | Students follow instructions while trying to answer specific smaller questions                                     |
| 8  | The above AND provides students with hints or info on answers to questions                                   | Students follow instructions while trying to verify answers to smaller questions                                   |
| 9  | The above AND provides info (lecture or text) in advance to guide investigation                              | Students follow instructions and try to verify factual knowledge in the lab  |
| 10 | The above AND explains important science concepts in advance including the expected outcome of investigation | Students form scientific ideas before investigation and do laboratory study to confirm what they already know      |

Different people use different words to describe what is meant by “inquiry” but three phrases that are fairly common are “discovery” (where students discover ideas on their own), “guided inquiry” (where ideas are generated by student investigations but those investigations are aimed at specific targets), and “traditional lecture/lab” (where ideas ultimately come from the teacher but lab investigation is used to reinforce those ideas).

Which forms of inquiry above (numbered 1 through 10) should we label “discovery,” “guided inquiry,” and “traditional lecture/lab”?

## Does inquiry and investigation *always* require an experiment? No.

Science does not always require experiments and neither does inquiry. OSPI specifically uses the word “Investigation” to mean an experiment or a field investigation (something akin to naturalistic observation of a system). Confusingly, “experiment” is not even a fifth grade WASL word even though field investigations are unlikely to appear on an elementary WASL exam.

### • Parts of an EXPERIMENT:

(*bold italics* are 5<sup>th</sup> grade WASL words or requirements)

*Question*  
*Prediction* } The hypothesis

*Materials* (in words – like a grocery list!)  
*Procedure* or *Plan* (diagrams are good)  
*Variables*

- *Controlled variables (kept the same)*
- *Manipulated variable (changed)* [Just one in a controlled experiment.]
- *Responding variable* (to look for an *effect* - which might not be there!)

#### *Observations*

- *Measurements* (the responding variable should be quantitative)
- *Repeated trials* (was the result just a fluke?)

*Recording* and Presentation of data (graphs? tables? labeled diagrams?)

Inference

Logical Steps (Analysis)

- When is the experiment is done?
- How will you recognize a result?

*Conclusion*

These don't necessarily appear in this order! Observations may suggest a question and a prediction may not appear until variables have been identified.

Which parts come from the teacher and which come from the students?

Different models of inquiry require different answers to this question.

## Rough generalization of the day:

IT IS INQUIRY IF:

*Some parts of the investigation are coming from the students and the students don't know the “answers” in advance.*

- **Parts of a FIELD INVESTIGATION:**

Field investigations are complicated and are not likely to show up on the 5<sup>th</sup> grade WASL. However, your students may want to *do* field investigations. They differ from experiments in some ways but the elements of inquiry are the same.

A field investigation is study that is done outside of a laboratory in a setting where completely controlled conditions are not possible.

*Example: A field biologist studying wild baboon behavior in an African savannah.*

The parts are the same except that:

1. The setting now enters into the procedure (and possibly into the materials).

*Example: The field biologist could choose to do an investigation in a clearing away from trees so that all baboons would be on equal footing.*

2. The “*variables*” are now defined by “characteristics” of the systems under study.

*Example: The field biologist could measure the times spent on grooming between baboons of different sizes. The sizes of the baboons would be the “manipulated” variable. The time spent on grooming would be the “responding” variable.*

3. Complication: It is almost impossible to completely control the other variables in conditions which makes interpretation of data difficult.

*Example: What are the ages of the different sized baboons? How is their health? What is their familial relationship? What is the history of their behavior in the troop?*

Only a very simple field investigation could appear on the 5<sup>th</sup> grade WASL (because of the complications cited in #3).

## **What constitutes a good investigation on the 5<sup>th</sup> grade WASL?**

1. Prediction
  - Bad: “Cotton will work better.”
  - Good: “Cotton will support more weight before tearing.”
2. Materials: A list that someone else could use to reproduce the investigation.
  - Bad: “I’ll need 2 kinds of cloth.”
  - Good: “1 sq. ft. each of cotton and wool.”
3. Variable kept the same (controlled variable)
4. Changed variable (manipulated variable)
5. Measured variable (responding variable)
6. Recorded measurements (*quantitative* and explicitly “recorded” or “written”)
7. Repeated trials (were the “results” just an accident?)
8. Logical steps (when is the experiment done? how do you interpret results?)

**To get full credit on WASL questions that require students to design an investigation, they must include all eight steps in their description.**

### **QUESTIONS TO PONDER:**

- 1. Do we discourage inquiry if we ask students to memorize the list?**
  
- 2. How much of the list could students create via inquiry?**
  
- 3. How could teachers help them to create it and remember it?**

## **TEN HOW-TO HINTS FOR TEACHING WITH INQUIRY:**

1. Ideas should come from students, so try not to give direct answers to questions. Answer questions with guiding questions. When in doubt, keep your mouth shut.
2. It is more important to be “minds-on” than to be “hands-on.” Keep the puzzle at the fore of students’ minds. Ask them why they are doing what they are doing.
3. Know your goal for each assignment. Is the main goal to learn about three phases of water or to have an authentic inquiry experience? The way you guide your students will differ accordingly. Assign some work with inquiry itself as the goal.
4. Remember, experiments never come out wrong. Mother Nature is always right. Some results come from variables we do not expect, but the results are not wrong.
5. Admit it when you don’t know. Try being wrong on purpose. Students should be confident that their observations are more important than someone else’s ideas.
6. Encourage students to try to be right but to relax about being wrong. We don’t want them guessing without thinking, but we don’t want them to obsess about getting the right answer. Students will learn more from their incorrect predictions.
7. Remain open to discovery and serendipity. Students will do things that you never imagined and sometimes those things lead to deeper insights than your lesson.
8. Build a community of scientists. Encourage talkative students to be quiet and quiet students to speak out. Be aware of personalities and create working teams.
9. Don’t stop at the end of the period. Use inquiry language for reading, art, and social studies. Work on reading, writing, and math skills during science class. Science often progresses in the absence of a lab and student understanding of science can grow from inferences about poetry, ball games, or chemicals.
10. Have fun. The students will if you will.

## HOW DO YOU ASK A QUESTION? WHY ASK IT THAT WAY?

Hints on answering questions with questions.

1. Always start with broad questions. “Can you think of another way to do it?” is probably better than “What if you did it with a rubber band and a ruler?”
2. Ask students to frame answers in terms of observations instead of preconceived notions. Prejudices are common causes of miscues and false assumptions.
3. Ask the same questions whether you agree or disagree with what is going on. Ask “Why are you doing it that way?” even if that is exactly the way you would do it. If questions are always the same then questions will not be intimidating.
4. By the same token, always ask whether students have considered other answers or other solutions. Even students who are on the right track will learn by considering alternatives (even if the alternatives are wrong).
5. Ask questions of individuals by name as well as questions of entire groups. The student who has said nothing may have the ideas that will get the group moving.
6. Allow students plenty of time to answer questions. Accept long silences and be prepared to let students think for several minutes before answering.
7. Encourage students to answer questions in ways that encourage different kinds of thinking. Ask them to draw diagrams or act out answers with their bodies. Ask them how they would explain things to students who do not speak their language.
8. Focus your questions on the way students frame their questions as well as on the answers they produce. Confusion may stem from poorly stated questions at hand.
9. Ask students about their mental models of what is going on. Students may be unaware that they have models unless they are compelled to articulate them.
10. Avoid pointing out unreasonable experimental results. Encourage students to compare results with those of others so that errors are found by the community.